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Diamond Light Source Proceedings / Volume 1 / Issue MEDSI-6 / October 2011 / e48
DOI: 10.1017/S2044820110000717, Published online: 21 December 2010

Diamond Light Source Proceedings, Vol 1, e48, page 1 of 4
MEDSI-6 2010

doi:10.1017/S2044820110000717

Poster paper

High heat load absorbers in Taiwan Photon Source storage ring

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(Received 10 June 2010; revised 11 October 2010; accepted 4 November 2010)

Taiwan Photon Source (TPS) is under construction at the National Synchrotron Radiation Research Center (NSRRC). This 518 m circumference synchrotron accelerator will generate 3 GeV and 500 mA high-energy X-rays. Absorbers in the storage ring will receive relatively high power densities (at a distance of 2.2 m from the dipole source). Three types of crotch absorbers for B1–B3 storage chambers were designed and prototyped. An end absorber in B3 is also designed and implemented to protect the downstream components in the chamber from being heated by the synchrotron radiation. Intensive vacuum brazing between Oxygen Free High Conductivity copper (OFHC) and stainless steel was carried out while fabricating the absorber assembly. The analysis, design and construction of several absorbers are reported in this paper.

1. Introductions

Taiwan Photon Source (TPS), a new synchrotron accelerator at the National Synchrotron Radiation Research Center (NSRRC), is under construction. This 518 m circumference ring will generate high-density synchrotron radiation with a beam energy of 3 GeV and a beam current of 500 mA. To protect the downstream ultra-high vacuum storage ring components, crotch absorbers are commonly used in the ring. In general, aluminium chambers in TPS are approximately 500 mm wide in the transverse direction near the crotch absorber location, which is around 2–3 m from the bending magnet source. Large pumping ports are located at the top and bottom of the chamber. Thus, the crotch absorber can only be installed from the side (from outbound direction). In addition, the size of the crotch absorber is limited to the chamber height (100 mm). This makes the absorber design a big challenge. There are three types of storage ring bending chambers in TPS: B1–B3. The 24 B1 chambers are for the ID beam to pass through, whereas the B2 (18 sections) and B3 (six sections) are for the bending magnet and IR beamlines, respectively. These three bending chambers have similar geometries but different lengths; thus, three types of crotch absorbers were also made to fit these three chamber types. The design and analysis of the crotch absorbers are discussed in the next section.

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2. Design and analysis

With 3GeV, 500mA design goal, as listed in Table 1, we summarize major parameters for each crotch absorbers as follows:

Crotch absorber type	B1	B2	B3
Distance from source (m)	2.3	2.7	1.9
Total length (mm)	531	548	388
Intercepted power (kW)	7.5	8.2	6.8
Vertical aperture (mm)	20	14	14
Horizontal aperture (mm)	50	50	50
Spring support	Yes	Yes	No
Total weight (kg)	10	11	9
No. of assembly required	24	18	6

TABLE 1. Design parameters of TPS crotch absorbers

Figure 1 shows downstream B1 storage chamber and its crotch absorber:

The location of the B3 crotch absorber is close to the bending magnet source. It intercepts less than 7 kW of power and leaves the rest of the synchrotron radiation to the end absorber. As shown in figure 2, the end absorber is installed from the top of the storage chamber. The copper cooling pocket was machined by electron discharge machining (EDM), and two 3/8 ft tubes were vacuum brazed onto the copper plug for a water inlet and outlet. These three absorbers are primarily for high heat load absorbers designed to shape bending magnet synchrotron radiation. A 60° V-shaped groove was fabricated on the surface where the bending magnet is heated. This groove minimizes back-scattering and reduces the power density. A

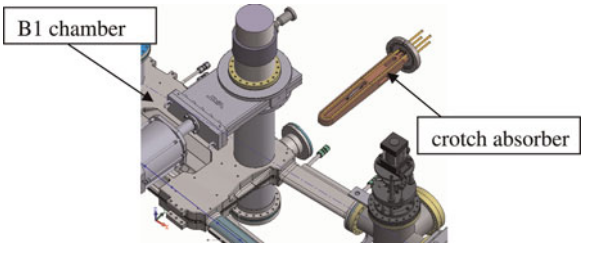

FIGURE 1. B1 storage ring chamber and crotch absorber.

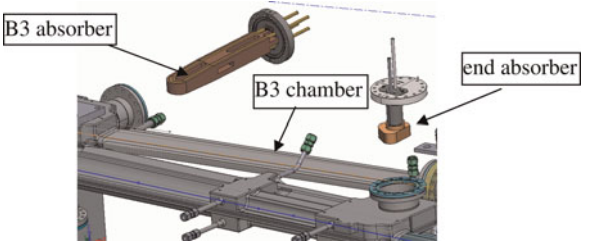

FIGURE 2. Crotch absorber and end absorber in a B3 storage chamber.

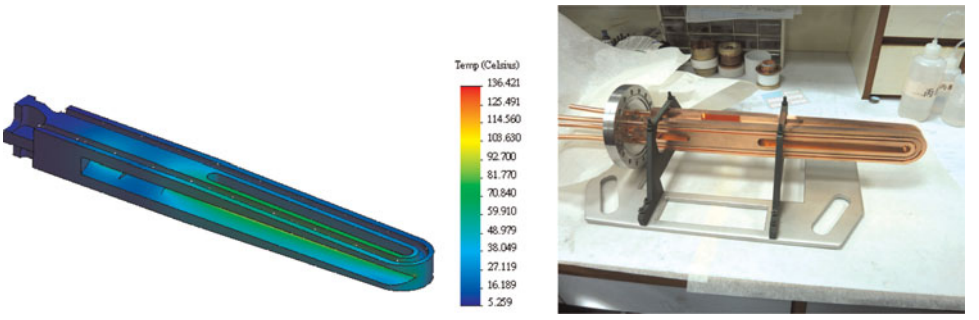

FIGURE 3. Temperature contour and B1 crotch absorber.

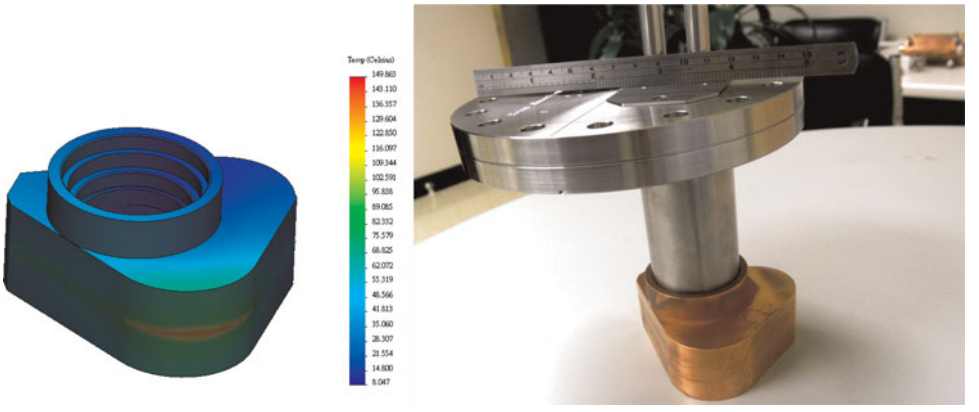

FIGURE 4. Temperature contours and prototype of end absorber.

thermal analysis for the B1 crotch absorber was carried out, and its temperature profile is illustrated in figure 3, assuming the water film coefficient in the water tube is 1 W cm^{-2} K^{-1}. At 500 mA and 3 GeV, the peak temperature increase of B1 crotch absorber was 136°C (assuming 0°C ambient temperature). The maximum water temperature increase of the tube was around 80°C. The maximum thermal-induced effective stress along the heating area was 120 MPa, which is still passively safe (Sheng *et al.* 2010).

An OFHC cooling body was brazed onto a 100CF stainless steel (SST) flange with a 50 Au/50 Cu brazing alloy. A brazing temperature of 970°C was used in a vacuum furnace. The purging (with dry N_2) was initiated after the brazed absorbers naturally cooled down to 380°C; it took about 3–4 h before the absorbers reached 50–60°C.

The end absorber will receive around 2 kW total power, and its corresponding temperature contour is illustrated in figure 4. The maximum temperature increase was 150°C. Thus, GlidCop® material will be utilized because of its high temperature and the thermal-induced stress.

3. Conclusions

B1–B3 crotch absorber prototypes were designed, analysed and fabricated. Thermal analysis suggests that the B3 crotch and end absorbers should

be fabricated using GlidCop, whereas the B1 and B2 crotch absorbers can be made of OFHC. Further brazing improvements and brazing quality control is in progress.

REFERENCE

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